

COMPONENT, IN PARTICULAR A DISPLAY APPARATUS

WITH ORGANIC LIGHT EMITTING DIODES

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Background of the Invention:

Field of the Invention:

The invention relates to a component, in particular to a display apparatus with organic light emitting diodes (OLEDs).

10 More specifically, the invention pertains to a planar electronic component having a functional layer which has an optoelectronic configuration or a circuit configuration and is disposed between a substrate layer and a covering layer, with a sealing frame or sealing ring which is likewise disposed between the substrate layer and the covering layer and connected to them by an integral joint surrounding the functional layer (3) against hazardous external influences, such as moisture and oxygen.

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For the present purposes, the functional layer may be a single layer or a layer assembly which is able to carry out specific electronic and/or optoelectronic functions.

25 The following description of the prior art and of the invention is based, by way of example, on a component in the

form of an OLED display. However, it should be understood that these specific references do not limit the invention to only such display apparatuses.

- 5   OLEDs (organic light-emitting diodes) have a number of advantages over conventional LCDs (liquid crystal displays): they have a low power consumption, require little area, have fast switching times over a broad temperature range from -40°C to 80°C and a wide viewing angle. It should not be forgotten  
10   that OLEDs are self-emitting and therefore do not require any separate back-lighting.

OLEDs have an organic light emitting layer between two electrodes. If a sufficient electrical potential is applied to  
15   the electrodes, the organic light emitting layer emits radiation as a result of the recombination of holes and electrons that are injected into the organic layer. The organic layer and the two electrodes are typically designed using thin-film technology and are applied to a substrate  
20   which, by way of example, is composed of glass. The side of the assembly of electrodes and the organic light emitting layer facing away from the substrate is covered by a further glass or metal plate, which is normally attached by way of an adhesive. The double-sided configuration of a substrate and of  
25   the further glass or metal plate as well as sealing means which surround the assembly formed by the electrodes and the

organic light emitting layer (referred to in the following text as an OLED assembly) and which are, for example, in the form of an adhesive ring results in the OLED assembly being largely hermetically encapsulated. This is necessary because  
5 the organic material and the electrodes are generally fairly sensitive to moisture and oxygen. Hermetic encapsulation such as this is therefore necessary for reliable operation.

In the configuration described above, the substrate and the  
10 glass or metal plate which is used as a covering layer are inflexible. However, for many applications, it is necessary for the component to have a certain amount of flexibility. Such flexibility with regard to bending loads may be necessary because the component is intended to be arranged on a base  
15 which is not flat, and is, more accurately, curved. Furthermore, such flexibility may be advantageous for the handling of the component, for example for a flexible or roll-up display.

20 In order to make it possible to produce a flexible component, a plastic substrate and a covering layer composed of plastic, for example, are used instead of the glass substrate and the glass or metal plate. However, the fact that the materials which are used are now flexible results in the requirements  
25 for the connecting technology between the substrate and the covering layer becoming more stringent, in order to provide

sufficient protection for the OLED assembly against moisture and oxygen. While adhesively bonded, i.e., glued, rigid configurations need to absorb only shear forces acting on the adhesively bonded joint, the substrate layer and covering 5 layer also have to be able to withstand tensile forces in flexible configurations, with tensile forces such as these occurring in particular in the edge area of the encapsulation where they place additional mechanical loads on the sealing means. The assembly comprising the substrate, the OLED 10 assembly and the covering layer also has to withstand the loads which occur during bending of the structure sufficiently in order to very largely avoid delamination of the substrate, OLED assembly and covering layer.

15 This problem is evident from the illustration shown in Figs. 1A and 1B.

Fig. 1A shows a plan view of an OLED display. Fig. 1B shows a cross section through the display along the section line I-I 20 shown in Fig. 1A.

An OLED assembly 3 is applied on a rectangular substrate 2 which is composed of a flexible plastic. By way of example, the OLED assembly 3 has an array of OLED pixels. Since the 25 basic design of OLEDs with an organic layer and electrodes is

known from the prior art, it will not be described in detail at this point or in the figures.

As can be seen from Fig. 1A, contact can be made with the OLED assembly 3 from the outside by way of connecting lines 6. The connecting lines 6 are applied on a surface of the substrate 2 and they extend from the OLED assembly 3 to the edges of the substrate 2. By way of example, the connecting lines 6 are arranged along two side edges of the OLED assembly 3 and, in a corresponding manner, along two side edges of the substrate 2. However, the route of the connecting lines is of no importance to the problem described in the following text.

As can be seen better from Fig. 1B, a covering layer 4 is disposed on the OLED assembly 3. The covering layer has a larger area than the OLED assembly 3, so that a rim of approximately the same size projects along all of the side edges of the OLED assembly 3. A sealing ring 5 is formed in this overlapping area and surrounds the OLED assembly 3, a short distance away from it. The sealing ring 5 has no interruptions whatsoever and serves to protect the OLED assembly 3 against external influences, moisture and oxygen. For this purpose, a close connection is provided between the sealing ring 5 and the covering layer 4 as well as the substrate 2.

The sealing ring 5 is composed, for example, of adhesive, which at the same time secures the mechanical connection between the substrate 2 and the covering layer 4. On the other hand, the adhesive is chosen with respect to its material 5 characteristics such that oxygen and moisture cannot get into the area or space enclosed by it.

Since both the substrate 2 and covering layer 4 are composed of flexible plastic, the component can withstand bending 10 loads. However, the reliability of the component is ensured only provided that there are no leaks between the sealing ring 5 and the substrate 2 or the covering layer 4.

Summary of the Invention:

15 It is accordingly an object of the invention to provide a component, in particular a display device with organic LEDs which overcomes the disadvantages of the heretofore-known devices and methods of this general type and which ensures its functionality even when bending loads occur frequently. One 20 particular object is to prevent the ingress of moisture and oxygen into the interior of the sealing ring.

With the foregoing and other objects in view there is provided, in accordance with the invention, a planar 25 electronic component, comprising:

a substrate layer, a covering layer, and a functional layer with an optoelectronic configuration or a circuit configuration between the substrate layer and the covering layer;

- 5 a sealing frame or sealing ring between the substrate layer and the covering layer, connected to the substrate layer and the covering layer by an integral joint, and surrounding the functional layer and protecting the functional layer against hazardous external influences (e.g., moisture, oxygen);
- 10 a mechanical connector with adhesive characteristics matched to the materials of the covering layer and of the substrate, the mechanical connector being disposed between the substrate layer and the covering layer and for fixing the substrate layer and the covering layer in a mechanically robust manner
- 15 with respect to one another.

The invention is based on the discovery that particular weak points of the component in Figs. 1A and 1B are present at the four corner areas of the substrate/covering layer assembly 4.

- 20 The covering layer 4 becomes detached from the sealing frame or sealing ring 5, with the hermetic encapsulation breaking down, even when subjected to comparatively small bending loads.

The invention therefore provides a connecting means for mechanical connection of the covering layer and of the substrate layer, whose adhesive characteristics are optimized both with respect to the covering layer and with respect to 5 the substrate layer. The primary or even sole task of the connecting means is thus to ensure the mechanical connection and fixing of the substrate layer with respect to the covering layer. Provided that these connecting means very largely prevent or minimize relative movement between the substrate 10 layer and the covering layer, the forces acting on the sealing frame or sealing ring are reduced or even absorbed completely. The risk of relative movement, which can result in particular in the covering layer or the substrate layer becoming 15 delaminated from the sealing ring, can be effectively reduced by the connecting means. This considerably improves the reliability of the component.

The technical teaching according to the invention furthermore allows a material to be chosen for the sealing frame or 20 sealing ring which is optimized primarily with respect to the capability for moisture and oxygen to pass through. In contrast, the adhesive force of the sealing ring with respect to the substrate layer or covering layer is of secondary importance for a component according to the invention.

According to one advantageous development of the component, it is sufficient for the connecting means to be arranged at points, in particular - when seen from the functional layer - outside the sealing frame or sealing ring which surrounds the 5 functional layer, in an area wherein the substrate layer and covering layer overlap. It is therefore not absolutely necessary to provide a ring surrounding the functional layer, whose adhesive characteristics are matched to the materials of the covering layer and of the substrate layer.

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The connecting means are preferably arranged in the corner areas of the assembly comprising the covering layer, the functional layer and the substrate layer. The mechanical connection of the corner areas considerably improves the 15 robustness of the entire component.

The feature referred to as the "corner area" or "corner" should in this case be interpreted as follows: if the substrate layer and the covering layer are of the same size, 20 that is to say these two components are arranged such that they essentially cover one another in a congruent manner, then the expression corner area means the corners of both the substrate layer and the covering layer. If, however, as is illustrated in Figs. 1A and 1B, the covering layer is smaller 25 than the substrate layer then the connecting means are arranged in the corner area of the covering layer. If the

substrate layer is smaller than the covering layer, this should in contrast be understood to be the corners of the substrate layer.

- 5 The connecting means are preferably formed by an adhesive joint, an ultrasound welded connection, a spot weld, a soldered joint, a screw connection, a rivet and/or a bracket, or by a combination of two or more of these means.
- 10 Alternatively or in addition to the described point connecting means, these connecting means may, according to one advantageous development, comprise a first reinforcing frame or ring which is arranged between the substrate layer and the covering layer, is closely connected to them, and encases the
- 15 functional layer. The first reinforcing frame or ring advantageously counteracts separation of the sealing frame or ring from the covering layer or substrate layer.

- 20 It is therefore particularly advantageous for the first connecting frame or ring to be arranged within the sealing frame or ring.

- 25 It has also been found to be advantageous for the connecting means to comprise a second reinforcing frame or ring which is arranged between the substrate layer and the covering layer, is closely connected to them, and likewise surrounds and

encases the functional layer. The second reinforcing frame or ring is preferably arranged outside the sealing frame or ring as seen from the functional layer.

- 5 Both the first and the second reinforcing frame or ring ensure a mechanically robust and firm connection between the substrate layer and the covering layer. The sealing frame or ring which is arranged between the first and the second reinforcing frame or ring may in contrast be optimized with  
10 regard to the capability for moisture and oxygen to pass through. In contrast, the first and/or second reinforcing frame or ring comprise a material the adhesive characteristics of which are optimized with respect to the substrate layer and with respect to the covering layer.

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- According to one development, the first and/or second reinforcing frame or ring may have interruptions. In particular, it may be advantageous for the second reinforcing frame or ring to fill the areas between two point connecting means. This allows the area of the covering layer to be kept small. It is likewise feasible for the first reinforcing frame or ring to have interruptions.  
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- Other features which are considered as characteristic for the  
25 invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in a component, in particular a display apparatus with organic light emitting diodes, it is nevertheless not intended to be limited to the details shown, since various 5 modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, 10 however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

15 Brief Description of the Drawings:

Fig. 1A is a plan view of a prior art OLED display device;

Fig. 1B is a section taken through the prior art device along the line I-I in Fig. 1A;

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Fig. 2A is a schematic plan view illustration of a first exemplary embodiment of a component according to the invention;

25 Fig. 2B is a section taken through the device along the line II-II in Fig. 2A;

Fig. 3A is a schematic plan view illustration of a second exemplary embodiment of a component according to the invention;

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Fig. 3B is a section taken through the device along the line III-III in Fig. 3A;

Fig. 4A is a schematic plan view illustration of a third exemplary embodiment of a component according to the invention; and

10 Fig. 4B is a section taken through the device along the line IV-IV in Fig. 4A.

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Description of the Preferred Embodiments:

Referring now once more to the figures of the drawing in detail, it will be noted that several of the underlying structural details described above with reference to Figs. 1A and 1B, also apply to the novel devices illustrated in the remaining figures. The exemplary embodiments of the invention refer back to the general design illustrated in Figs. 1A and 1B and they have, furthermore, connecting means according to the invention that result in a considerable improvement in reliability.

A functional layer in the form of an OLED assembly 3 (see Fig. 2B, which shows a section along the line II-II from Fig. 2A) is arranged between a substrate layer 2 and a covering layer 4, both of which are composed of a flexible material, such as 5 a plastic. The OLED assembly 3 represents, for example, an LED array composed of OLEDs. The component is thus in the form of a display device. Instead of the OLED assembly 3, it would also be possible to provide a solar cell or any other integrated circuit, preferably based on organic materials.

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As can be seen better from Fig. 2A, the OLED assembly 3 is surrounded by a sealing ring 5. The sealing ring 5 is closely connected to the covering layer 4 and to the substrate layer 2, as can be seen in Fig. 2B, in order to hermetically protect 15 the enclosed OLED assembly 3 against external influences.

In order to prevent the covering layer or the substrate layer 2 from being detached from the sealing ring when bending occurs, point connectors 7 are also provided in the corner 20 areas of the covering layer 4. The point connectors or point connecting means 7 are, for example, adhesive droplets, whose adhesive characteristics are matched to the materials of the substrate 2 and of the covering layer 4.

25 The material characteristics of the sealing ring 5, which admittedly also represents a certain amount of mechanical

connection between the substrate layer 2 and the covering layer 4, can be optimized with regard to the ability for oxygen and moisture to pass into the inner space housing the functional layer 3, due to connecting means 7 that are 5 provided.

Due to the reinforcement of the corner areas by way of the connectors 7, the robustness of the component is improved to a considerable degree. A test configuration wherein the outer 10 corners of the covering layer 4 are reinforced by means of adhesive droplets withstood 100,000 bending cycles without being damaged, with a bending radius of 20 mm being used. A component as shown in Fig. 1 that was subjected to the same loads was damaged even after a considerably smaller number of 15 bending cycles. Even better robustness is achieved by using a connection by way of ultrasonic welding instead of point adhesive spots.

The advantage of the component according to the invention is 20 in particular that no modification whatsoever is required to known components. The material characteristics of the sealing rings, which are known by the expression "low permeation glue," are optimized with regard to moisture and oxidation, and can still be used. These sealing rings effectively prevent 25 the ingress of moisture and oxygen, while the connecting means

according to the invention ensure the robustness and reliability of the component.

The point connections 7 shown in Fig. 2 may also be produced  
5 by soldering, brackets, screws, rivets, or welding.

Figs. 3A, 3B show a further development of the component according to the invention. Once again, Fig. 3A shows a plan view of the component according to the invention, while Fig.  
10 3B shows a cross section along the dashed-dotted line III-III from Fig. 3A.

Experiments have shown that the inner rim of the sealing ring  
5 may be a further weakness. This weakness is particularly  
15 evident when the point connections 7 are used.

In order to prevent the sealing ring from being detached  
(delaminated) from the covering film 4 or from the substrate  
layer 2, a first reinforcing ring 8 is therefore provided.  
20 When seen from the OLED assembly 3, the reinforcing ring 8 runs within the sealing ring 5, and will therefore be referred to in the following text as the inner reinforcing ring. Like the sealing ring 5, it also surrounds the OLED assembly 3.

As is shown in Fig. 3A, the inner reinforcing ring 8 may be formed without any interruption. However, it is also feasible for interruptions to be provided.

- 5 The adhesive characteristics of the inner reinforcing ring 8 are optimized with respect to the covering layer 4 and the substrate layer 2. No particular requirements have to be met with respect to the capability of moisture or oxygen to pass through. This protective task is carried out by the sealing  
10 ring 5.

The third exemplary embodiment shown in Figs. 4A, 4B has a second reinforcing ring 9 added to it. The second reinforcing ring 9 is also referred to as the outer reinforcing ring since  
15 it is arranged outside the sealing ring 5, when seen from the OLED assembly 3.

In order to make it possible to design the area of the covering layer 4 to be as small as possible, the outer  
20 reinforcing ring 9 is subdivided into sections, which each extend between two point connections 7. Interruptions 10 are thus provided between a point connection 7 and a section of the outer reinforcing ring 9. As can be seen from the section of the outer reinforcing ring 9 shown on the right in Fig. 4A,  
25 the section may also itself have interruptions .10. In contrast

to the illustration the interruptions may in this case be provided in each of the four sections.

The exemplary embodiments which are illustrated in Figs. 2 to 5 4 may, for example, represent a matrix display. A matrix display which operates on the basis of light emitting polymers is arranged on a flexible plastic substrate in a known manner. A covering layer which is composed of plastic is then adhesively bonded to the arrangement, with an adhesive through 10 which little moisture and oxygen can pass surrounding the light emitting polymers. Point connections are then produced in the corner areas of the covering layer by means of ultrasound welding. This results in a mechanically robust component which is protected against environmental influences 15 and at the same time has a good bending capability.

Furthermore, the component according to the invention could be represented by a flexible light source which is produced as described above.

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It is also within the scope of the invention for the functional layer to be in the form of a solar cell composed of conjugated polymers. Furthermore, a large number of further applications are feasible, in particular for organic detectors 25 as well as integrated circuits based on polymers.

The foregoing description of the invention with reference to its implementation as an OLED display component should not be understood that the invention relates exclusively to display apparatuses such as these. In fact, the invention can also be  
5 used, *inter alia*, for integrated circuits, solar cells, sensors and detectors, based in particular on polymers, and the like.

This application claims the priority, under 35 U.S.C. § 119,  
10 of German patent application No. 103 14 522.2, filed March 31, 2003, and of German patent application No. 103 29 366.3, filed June 30, 2003; the disclosures of the prior applications are herewith incorporated by reference in their entirety.